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Weather and Spray Drift: Part I: Some misconceptions*

by R.J. Adams

1. Introduction

Although it has long been recognised by the farming community that the manner in which spray materials drift is influenced by meteorological factors - the most obvious being the dependence upon wind speed - there appears to have been only very limited guidance given to farmers which might help them to decide the conditions which are 'suitable' for spraying ('suitable' in the sense of avoiding damage through drift, not in terms of efficacy of the actual treatment). This memorandum and its companion ** attempt to correct this situation, by describing methods by which the drift hazard may be quantified (Pt II) and related to meteorological factors: Part I introduces the subject by identifying what are felt by the authors to be commonly held misconceptions concerning the relationship between weather and spray drift.

These misconceptions have probably continued uncorrected because virtually all the information available on the subject has appeared in scientific journals, recommendations of Technical Working Groups, or in guidance to weather forecasters. In short, the information has not been directly available to farmers. They base their understanding on observation, common sense, and, when technical data are required, on professional advice or the manufacturer's label. However, the last named source, although frequently referring to the meteorological conditions under which the particular compound should be applied, rarely makes reference to the problems of drift - except perhaps that 'it is to be avoided'. Creditable attempts to do somthing better have often been rather misleading because the authors of these were often suffering from the same miscoceptions as the farmers themselves, so it is perhaps worth considering the probable reasons which generated the misconceptions in the first place. It is felt that most of these have arisen because those responsible for actually undertaking spraying operations will judge the extent and severity of spray drift on the basis of two simple, but rather unreliable methods:-

2. 'Field' methods of assessing spray drift

2.1 Direct visual observation of drifting drops.

The success of this method depends on the viewing conditions, particularly with respect to the relative positions of the source of light, drops and observer, and the background against which the drops are viewed. Objects such as spray drops are made visible through the light which they scatter (MAINLY in a forward direction) and so the optimum position for viewing occurs when the observer has the drops situated between himself and the

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* This Ag. Memo. is intended to be preparatory to an article in the 'popular' farming press.

** Weather and crop spraying Part II: Some quantifications, by N. Thompson (Ag. Mem. No. 908).

source of light, which is usually the sun. Of course even if this is achieved he is then likely to be viewing against the much brighter sky background which makes the small drops impossible to see. Conditions for viewing are much better when spraying is taking place at night under artificial light. Indeed, those farmers who are now following this practice often express astonishment on seeing the extent to which drops are failing to reach their intended targets.

2.2 Observation of subsequent damage attributable to spray drift.

If the crop in a field adjacent to another which has been sprayed with a herbicide subsequently shows obvious symptoms of herbicide damage to a distance of a few metres into the crop, then the most obvious inference is that the cause of damage was drifting spray. Suppose the damage is observed 10 metres into the crop. The farmer might deduce that the spray drops have drifted 10 m and no further. But can he be sure of this? The answer is clearly no - the correct deduction is that the herbicide concentration has been sufficiently high to exceed some damage threshold value for up to 10 m. Some of the drops may have drifted much further.

3. Misconceptions regarding the association between meteorological factors and Spray Drift

3.1 Misconception 1 - Drift distance.

Spray drops only drift up to 10-20 metres, and then only under drift conducive conditions which the farmer would normally avoid. WRONG!

3.2 Misconception 2 - Relationship with wind speed.

As wind speed decreases, so does the risk of spray drift, to become almost negligible under near calm conditions. WRONG!

The two main factors which have been overlooked by those who would consider the previous statement to be true are:

(a) the directional variability of light winds

(b) the tendency of the smaller drops to behave more like a cloud carried up and down by air currents, than as individual 'heavy' particles which fall rapidly to the ground dominated by the force of gravity.

Suppose an operator commences spraying a herbicide following the observation that the light wind is blowing in a direction which will not cause drifting of the spray onto a nearby susceptible crop. He must not assume that this situation will continue for anything like the full period necessary to complete the spraying operation.

Most farmers would readily, and correctly, accept that spraying in windy conditions is unwise (because the larger drops which contain most of the active ingredient drift further in a strong wind). The misconception lies in assuming that the converse is true, ie that spraying in a light wind is without risk.

The motion of the larger drops is primarily controlled by gravitational forces. Consider a spray drop of 250 µm ($\frac{1}{4}$ mm) diameter. If released from a height of 0.5 m gravity would dictate that it would take about $\frac{1}{2}$ second to reach the ground. If the horizontal wind speed were 6 m sec^{-1} then it would travel 3 m in this time. However, if the drop was much smaller, say 50 µm (1/20 mm) diameter, it would no longer be correct to assume that the time taken to reach the ground would be that dictated by gravity (about 7 seconds). Thus a calculation of drift distance (about 40 m in this case) based on this assumption would be incorrect. This is because the vertical motion of the smaller drops is controlled primarily by atmospheric turbulence. Under these circumstances, predictions of spray drift have to be concerned with the movement of the whole 'cloud' of drops - eg with quantities such as the position of peak deposit, and the proportion of the total number of drops deposited at a given distance downwind. This is of course to a considerable extent also true of the larger drops, but in that case the prediction of the motion of individuals can provide useful information, for the smaller drops it does not. One of the interesting consequences of considering the spread of a cloud of small drops under certain quite commonly occurring atmospheric conditions is that the distance downwind of the peak deposit is relatively independent of wind speed ie they go as far in a light wind as in a strong one. Although this finding is perhaps not universally accepted it is quite clear that there is very little decrease of drift risk of small drops as wind speed decreases (but the number of drops produced as drift may decrease; see Part II).

Coupled with the increased directional uncertainty of light winds (which affects all drop sizes) there is a strong case for arguing that spraying in very light winds can be at least as hazardous as spraying when the wind is strong.

3.3 Misconception 3 - Temperature and Volatility.

Volatile materials generally vaporize more rapidly at high temperatures - RIGHT! Therefore the risk that drift damage will occur must decrease if volatile materials are only sprayed when the temperature is low. WRONG!

There is very strong experimental and field evidence to show that susceptible crops have suffered from airborne transfer of certain herbicides following spraying operations when there was virtually no chance that the transfer could have taken place at the time of spraying. The conclusion of those who have conducted these experiments is that the only possible mechanism for transferring the herbicide was by vapour drift, with at least some of the vapourisation taking place some time after the liquid drops had reached their intended target.

Clearly, any vapour given off at the time of spraying only represents a hazard to suceptible crops if it drifts onto them in such concentration as to cause damage. In this respect vapour drift is no different from that if liquid drops, so if conditions are truly such to present no hazard from the drift of very small drops, then there is unlikely to be any additional hazard to crops from vapour drift which occurs at the time of spraying whatever the temperature. The additional hazard incurred through the use of

volatile materials stems from the possibility that the temperature will be such to cause vapourisation of any residue left on the crop or soil after spraying has ceased, at a time when the wind direction may be such to carry the vapour to the susceptible crop. However, conditions occurring at some rather ill-defined period in the future, are, in the sense implied here, independent of those existing at the time of spraying. Thus the spraying in low temperature conditions does not decrease (and may even icrease) the possibility of vapourisation occurring at the time when the farmer has no control over its effects, namely after the spraying operation is completed.

NB: The advice to avoid spraying in high temperatures is, however, generally quite sound, but for a different reason, namely that high temperatures are frequently associated with light and variable winds, and stability conditions conducive to increased drift, especially when sprays containing small drops or vapours are involved.

3.4 Misconception 4 - Concentration of active ingredient.

If 99.9% of the sprayed material reaches its intended target, the rest can be ignored. WRONG!

The amount of liquid, and hence active ingredient, contained in a drop is proportional to its volume, ie to the cube of its diameter, (so that, for example, a drop of diameter 150 μm contains 27 times as much active ingredient as one of 50 μm. Thus if one calculates the amount of active ingredient associated within a particular size interval of the drop size spectrum of the spraying device, it is usual to find that only a very small proportion of the active ingredient is contained in the drift prone small drops (or vapour).

But this is of course in itself no reason for supposing that very small concentrations of chemical will not be damaging to susceptible crops. If x parts per million incident on the non-target crop exceed the threshold of damage it is immaterial whether this constituted 10% or 0.01% of the amount which left the sprayer. This rather obvious statement should not, but has in fact, been frequently overlooked by over-zealous spokesmen wishing to discount the possibility of damage having occurred through the use of their products.

4. Conclusion

Only when the two questions (i) 'How much (if any) toxic material can reach a susceptible crop?', and (ii) 'How much is needed to cause damage when it gets there?' have been answered, can the full assessment of drift hazard of a particular material and its use in given circumstances, be made.

Part II explores quantitative approaches intended to supply answers to the first of these 2 questions.

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Comments on the contents of this report are welcomed by the author.